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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANTS	Daniel R. Dorrance et al.
SERIAL NO.	10/682,247
FILED	October 9, 2003
PAT. APP. PUB. NO.	US 2005/0078304 A1
PUBLISHED	April 14, 2005
EXAMINER	Isam A. Alsomiri
GROUP ART UNIT	3662
FOR	COMMON REFERENCE TARGET MACHINE VISION WHEEL ALIGNMENT SYSTEM

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THIRD-PARTY SUBMISSION
IN PUBLISHED APPLICATION
UNDER 37 CFR 1.99(A)

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

The following information is submitted as relevant to the examination of U.S. Patent Application No. 10/682,247, published as U.S. Patent Application Publication No. 2005/0078304 A1 on April 14, 2005. This submission is submitted within two months from the publication date of the application pursuant to 37 CFR 1.99(e). Please charge the fee as required by 37 CFR 1.99(b)(1) and set forth in 37 CFR 1.17(p) in the amount of $180.00 to Deposit Account 500417.

06/08/2005 HALI11 00000055 500417 10682247
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WDC99 1088581-1.010473.0110

A duplicate copy of this submission has been served to the Applicants' Correspondence Address listed on the face of the U.S. Patent Application Publication as required by 37 CFR 1.99(c).

LIST OF PATENTS/PUBLICATIONS

1. Selected pages of U.S. Patent No. 5,724,743 to Bernie Fergus Jackson for "Method and Apparatus for Determining the Alignment of Motor Vehicle Wheels", issued on March 10, 1998, including cover page, Figure 9 and column 22, lines 1 through 25.

2. U.S. Patent No. 5,809,658 to David A. Jackson et al. for "Method and Apparatus for Calibrating Cameras used in the Alignment of Motor Vehicle Wheels", issued on September 22, 1998.

3. U.S. Patent No. 6,148,528 to Bernie Fergus Jackson for "Method and Apparatus for Determining the Alignment of Motor Vehicle Wheels", issued on November 21, 2000.

4. U.S. Patent No. 6,115,927 to Bill Hendrix for "Measuring Device Primarily for Use with Vehicle", issued on September 12, 2000.

5. Selected pages from U.S. Patent No. 6,731,382 to David A. Jackson et al. for "Self-calibrating 3D Machine Measuring System Useful in Motor Vehicle Wheel Alignment", issued on May 4, 2004, including cover pages, Figures 6b and 8, and written descriptions.

6. Selected pages of Form 5489-5, Visualiner 3-D™ Installation Instructions, DOS Version 2.04 Software, Pro32 Windows 95 Software, Published April 5, 2001, including cover page, pages 37-41 and page with copyright notation.

7. Selected pages of Form 5576, Visualiner 3D Service Manual, Published March 15, 1999, including cover page and pages 7, 8, 20-23 and 104.

8. U.S. Patent No. 6,424,411 to Rapidel et al. for "Optical Installation and Process for Determining the Relative Positions of at least Two Objects in Space", issued on July 23, 2002.

9. U.S. Patent No. 6,839,972 to Jackson et al. for "Self-calibrating Position Determination System," issued January 11, 2005

Please charge any shortage in fees in connection with this submission to Deposit Account 500417.

Respectfully submitted,

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I hereby certify that a copy this correspondence and all attachments is being deposited with the U.S. Postal Service on **June 7, 2005**, in compliance with 37 CFR 1.99(c) and 37 CFR 1.248(a)(4), as first class mail in an envelope addressed to:

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06/07/2005

Date of Signature

WDC99 1088581-1.010473.0110

Visualiner 3-D™

Installation Instructions

DOS Version 2.04 Software
Pro32 Windows 95 Software

Form 5489-5

Revision 04/05/01

17. Collapse the calibration fixture and prepare it for RCP (Relative Camera Positioning).

18. Press **ESC** (escape) on the console keyboard to exit the program and return to the Start Menu.

VIII. RELATIVE CAMERA POSITIONING (RCP)

The purpose of the camera calibration procedure is to measure the cameras' positions relative to each other. This allows the aligner to make accurate measurements between the left and right sides of the vehicle.

Note: Relative Camera Positioning is normally done at installation time only.

Tools needed: Aluminum or Fixed-Length Steel Fixture with two targets.

1. Raise the empty lift to working height (no vehicle). Close the garage door to block any stray daylight.

2. Prepare the Calibration Fixture as shown in the Camera Aiming Instructions. On the Aluminum fixture, do not unfold the bar extensions shown in step 5.

3. Clean the two targets on the fixture, according to the user manual. Use a glass cleaning fluid and a soft cloth. Make sure that the glass is free from grease and dirt.

4. From the Start Menu, go to "Setup utils", enter the password **iasetup**, then "Rel Cam Pos (RCP)", and press Enter. This initiates the RCP program.

5. The program starts up and display the following message:

```
*************************************************************

Slide the Right turntable to its outboard position. Place the

Calibration Fixture on the Right Rack Runway with the

Small Target on the outside of the turntable and the Large Target

towards the Rear in the Center of the runway. Press Y when done

*************************************************************
```

   Place the fixture as instructed and press Y (yes) on the keyboard.

6. After a period of time, on the screen, you will see the message:

```
*************************************************************

Extend the 1 1/2 inch plunger under the rear foot. Press Y when done
```

```
***************************************************************
```

On the rear foot of the calibration fixture, you will find a "Plunger Knob". The purpose of this knob is to act as a 1 1/2" shim for tilting the fixture. To actuate the knob, twist to unlock, press in, and twist again to lock. This raises one foot of the fixture and sets the targets back for a slightly offset viewing angle. When the fixture is in place with the knob up, press Y (yes).

7. After a period of time, you will see the message:

```
***************************************************************

Retract the 1 1/2 inch plunger under the rear foot

Place the Calibration Fixture on the Rack with the Small Target on the

Right Turntable and the Large Target on the Left  Turntable

(you may need to slide the turntables in). Center the bar

front to rear on the turntables.  Press Y when done.

***************************************************************
```

Retract the plunger to make the fixture level once again. Then move the fixture as instructed and press Y (yes).

8. After a period of time, you will see the message:

```
***************************************************************

Move the Calibration Fixture back approximately 2 feet. Press Y when done

***************************************************************
```

Move the fixture about two feet toward the rear of the rack, keeping it parallel to the camera beam. Press Y (yes) when ready.

9. After a period of time, you will see the message:

```
***************************************************************

Move the Calibration Fixture back approximately 2 feet. Press Y when done

***************************************************************
```

Move the fixture about two feet farther toward the rear of the rack, keeping it parallel to the camera beam. Press Y (yes) when ready.

10. After a period of time, you will see the message:

```
*************************************************************

Move the Calibration Fixture back to the turntables. Press Y when done

*************************************************************
```

Place the fixture's feet back on the two front turntables and press Y (yes).

11. After a period of time, you will see the message:

```
*******************************************************************

Slide the Left turntable to its outboard position. Place the

Calibration Fixture on the Left Rack Runway with the Small Target

in the center of the turntable, and the Large Target towards the rear

on the outside of the Runway.  Press Y when done.

*******************************************************************
```

Place the fixture as indicated and press Y (yes).

12. After a period of time, you will see the message:

```
*************************************************************

Extend the 1 1/2 inch plunger under the rear foot. Press Y when done

*************************************************************
```

Engage the "plunger knob" and press Y (yes).

13. After a period of time, you will see the message:

```
*************************************************************

You Have Successfully Completed Calibration Press Y

*************************************************************
```

This indicates that you have successfully completed the camera calibration procedure. Press Y

14. The following prompt appears:

```
Ready [Y/N] :
```

Press Y. This exits the RCP routine and displays the following text as the routine closes:

```
Exit Enabled:startFreeMemory= 12363Kb, endFreeMemory= 11626Kb
```

15. Collapse or disassemble the Aim/RCP fixture and store it in a safe place.

RCP Notes:

> Some time elapses between each step of the RCP process, in some cases as much as a couple of minutes. If the program does not seem to be progressing, examine the targets for dirt or grease, and then move the calibration fixture a small amount and observe the on-screen view's response. If there is no response it will be necessary to reboot the computer and restart RCP.

> During the RCP steps you may see a message appear stating "**Plane 1 of 3 is Outlier ...**". This usually occurs if the target position changes during the time when the software is examining the targets (i.e. you are still moving the fixture). These error messages have no bearing on the outcome of RCP and can be ignored.

> The final steps of RCP check the dimensional integrity of the fixture during the procedure. If the fixture has physically changed is dimensions the software returns a message concerning an "RTP Error" exceeding a tolerance of 0.800. RTP stands for Relative Target Position, meaning that the position of the targets on the fixture has changed. Recheck the tightness of all fasteners and repeat the RCP procedure using extreme care when moving the fixture around. **RCP MUST BE SUCCESSFULLY COMPLETED BEFORE ANY ALIGNMENTS ARE PERFORMED.**

> You may see the error message:

**"Cannot find the large (or small) target is blocked or dirty,
look at the display above"**

This means that the camera can not see the entire target for some reason. The camera must be able to clearly see the whole target. Find out what is blocking the camera's view, using the image display, and remove the obstruction. If there is no apparent reason for this message simply wait – the software usually locates the target within 30 seconds.

> You may see one of these messages:

```
"Raise the small (or large) target"
"Lower the small (or large) target"
"Move the small (or large) target to the right"
"Move the small (or large) target to the left"
```

This indicates that the target should be physically moved about 2 inches. Wait for a few seconds to see if the message goes away, if not move another 2 inches until it does.

> The cameras must be calibrated whenever a camera's position changes relative to the other camera. The beam normally secures both cameras in a fixed position, but it is possible for one or both to be knocked out of position.

Camera relative positions will change, requiring a new RCP, under the following circumstances:

- A camera has been removed for any reason, or if the camera has been replaced
- The cameras have been re-aimed
- A camera pod or the beam has been hit by a heavy object
- The aligner has been moved to a different location

- After a major earthquake or other natural event

Camera calibration is NOT necessary when the entire camera beam or console is moved slightly without disturbing the cameras' position relative to the beam.

IX. TARGET ID PROCEDURES

The purpose of the Target Identification procedure is to geometrically characterize each target's position relative to its rim clamp assembly. This allows the aligner to later accurately compute the position of the wheel when the rim clamp is attached.

The Target ID procedure is normally done only once at installation time. If a target or rim clamp is ever replaced for any reason, the new target should be identified using this procedure after it is installed.

Tools Required: No special parts are needed - only the aligner and the targets that are used in normal operation. A carpenter's angle protractor may aide achieving target rotation angles.

NOTE: With Pro32 software, Target ID can be performed within the software's user interface or by using the Start Utilities accessed from the Windows desktop – the results are the same. The following procedures describe Target ID using the DOS Start Menu and Setup Utilities. See Page 45 for instructions on how to perform TID within the Pro32 program.

DOS Start Menu Procedures

1. Select a vehicle with wheels that are reasonably good condition and drive it onto the rack. Raise the car to normal working height on the lift or rack. Close the garage door to block any stray daylight.

2. Clean the targets thoroughly with a glass cleaner solution and soft cloth.

3. Make sure the aligner and Camera Beam are powered ON.

4. From the Start Menu, select "Setup utils", then "Target Id. (CLAWS)", and press Enter.

5. The Target ID program will start up and display the following message:

   `"Jack front axle.  Straighten and lock steering wheel.  Ready [Y/N]"`

   Jack up (raise) the front axle of the car so that the front wheels are about 1/2 inch off the runway. Set the steering wheel straight ahead and set the steering lock so that it remains stationary.

6. On the keyboard, type **Y <enter>**.

7. You will see the message:

   `"Target to ID (LF , RF , LR , RR , else EXIT) [Exit]"`

   Each Target ID must be done independently. This asks which of the four targets will be identified first.

8. Type **"LF <enter>".**

   This selects the left front target for identification.

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Visualiner 3D

Service Manual

Form 5576

Rev. 031599

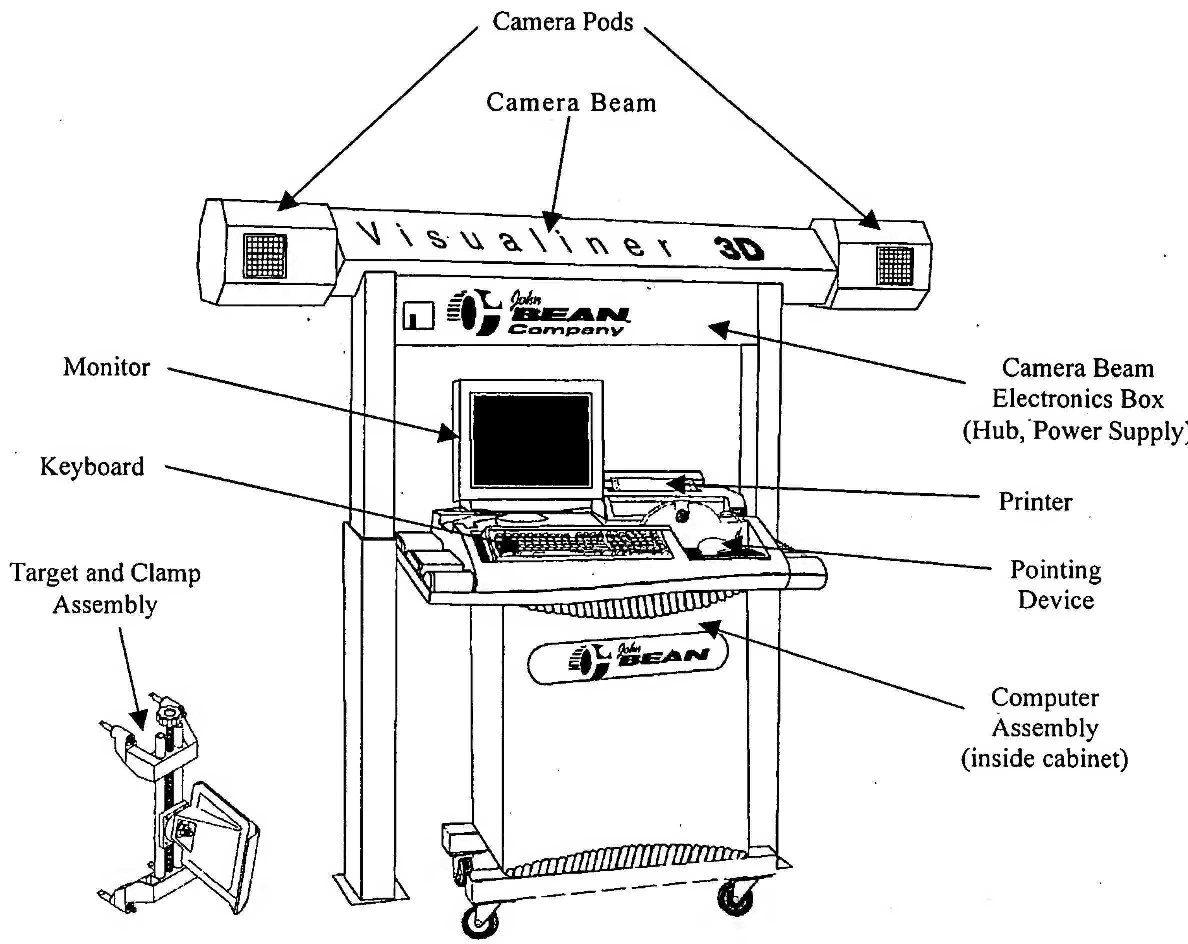

Figure 1. 3-D Aligner Components

Cameras

The "eyes" of the vision-based 3-D Aligner are the two cameras mounted on either end of a camera beam. The cameras are mounted inside of an assembly called the Camera Pod that attaches to the Camera Beam with three screws. The cameras are high-resolution CCD video type operating in gray-scale, similar to those used in security and surveillance applications. The lens is a special design for this usage, and is permanently mounted to the camera and sealed for protection. The camera also has a band-pass filter, limiting the spectrum of light that can enter the lens.

With any camera there is an optical "field of view" that is a characteristic of the lens design. Anyone who has used a camera or single lens telescope knows that what you see is what you get – no more, no less. The cameras on the 3-D Aligner are no different. The field of view is located along each side of the alignment rack and is a cone-shaped "tunnel" that expands in size as it moves further away from the cameras (*Figure 2 and Figure 3*). The tunnel is approximately two feet in diameter near the front turntables. The centerlines of the tunnels are close to vehicle spindle height and about 15 inches outside of the outer wheel surface of an average car. In fact, the cameras are initially aimed upon aligner installation so that the targets, when mounted onto

an average vehicle, would be located in the center of that tunnel. This insures that any vehicle placed on the rack in front of the 3-D Aligner, from the widest to the narrowest, will have the targets mounted within the cameras' field of view. If any target is outside of the field of view the aligner will not work.

Figure 2. Camera Field of View – Side View

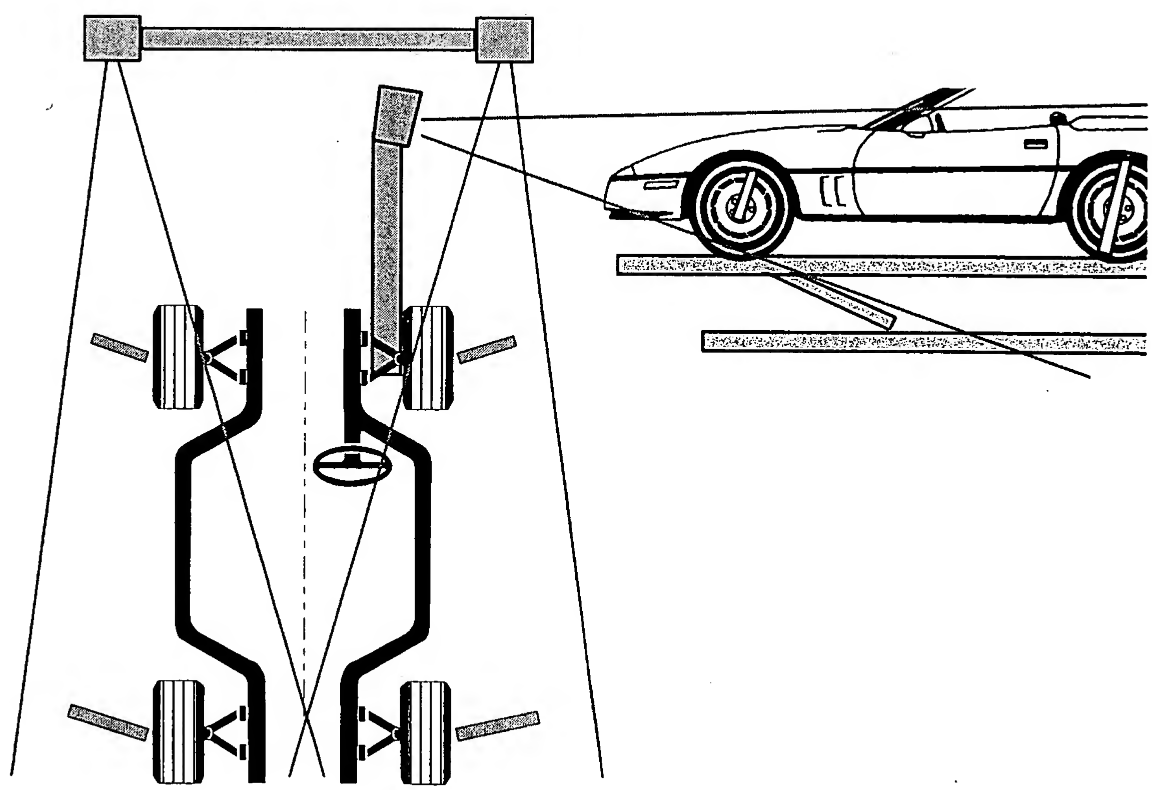

Figure 3. Camera Field of View – Top View

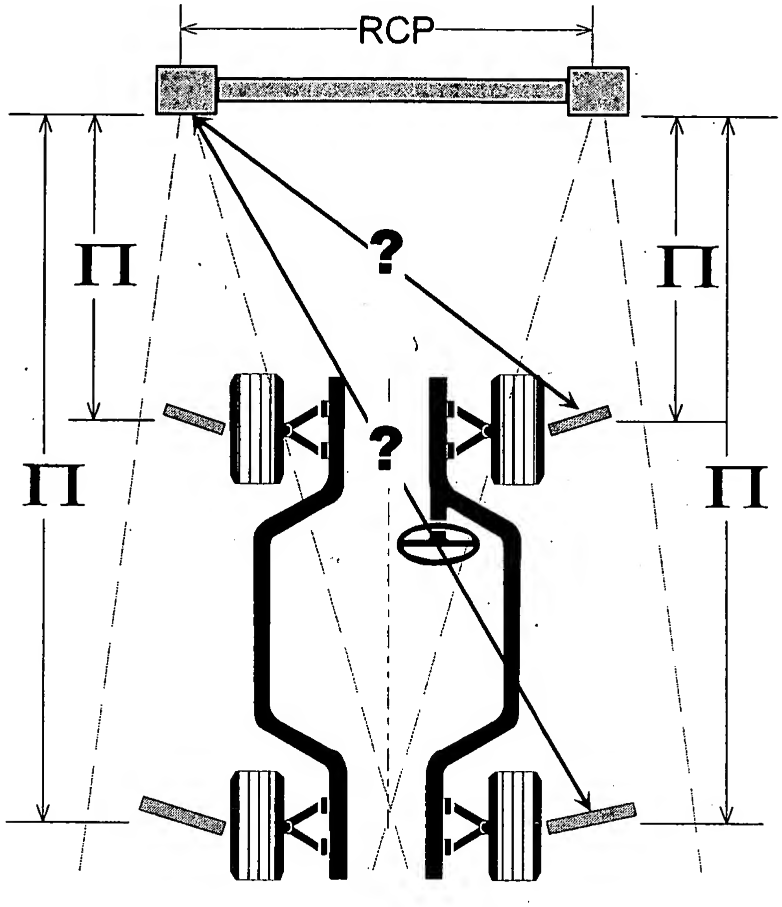

Figure 14. Side to Side Determination and RCP

Relative Camera Positioning (RCP)

It would be easy to say that we know the distance between the cameras because we designed and manufacture the Camera Beam and cameras. However, the knowledge the aligner must have about the relationship of one camera to another is critical and must be known to high level of precision – manufacturing tolerances in the beam and camera assemblies are too variable to be counted on.

When the aligner is installed the technician mounts the cameras onto the beam. Later, the technician performs a camera aim in which he/she alters the position of the cameras. Once all camera movements are completed it is time for us to help the program find out where the cameras are with respect to each other. We must perform Relative Camera Positioning.

The Fixture

The fixture used to perform RCP is also used for camera aiming. It consists essentially of a bar about 5.5 feet in length with a target attached on each end (a front and rear). Stands are used to place it on the alignment rack, which should be at alignment height so the targets are visible to the cameras.

Step 1. Measure the Fixture Length

Due to manufacturing tolerances and transportation of the fixture, we cannot be sure its dimensions are the same as the design. We must measure it each time we perform RCP. Of course, we always have a highly accurate measurement tool at our disposal – the 3-D Aligner.

To measure the length of the fixture we place the assembly on the right runway of the rack in the view of the right camera (see *Figure 15*).

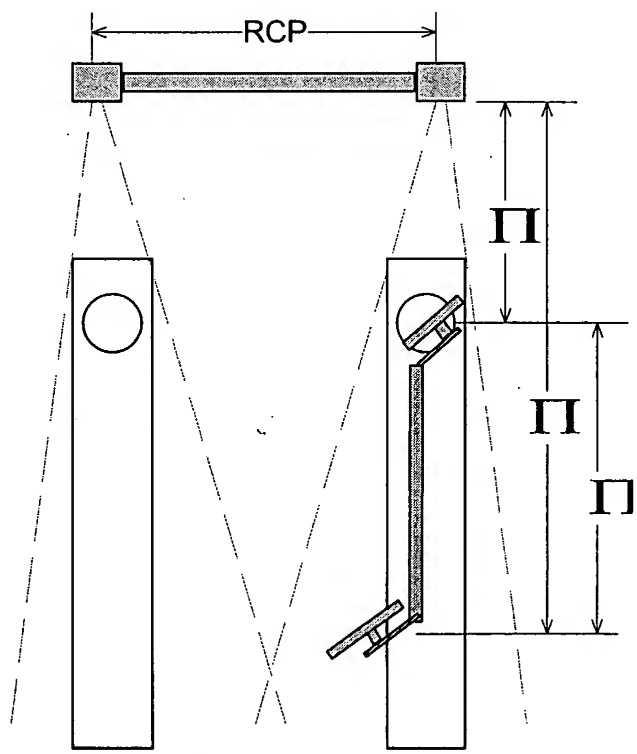

Figure 15 RCP Step 1

The right camera measures the distance to the front target and the rear target, and subtracts the two with the difference being the fixture length. This is stored in memory for usage later in the RCP procedure.

Step 2. Determine Relative Camera Position

Next, we take the fixture of a length we now and place it across the runways, placing one target in the left camera's vision and one target in the right camera's vision (see Figure 16).

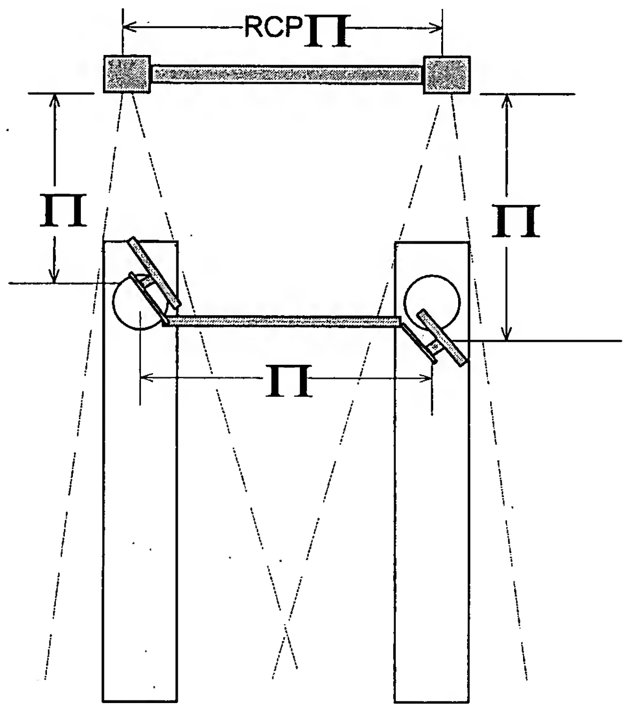

Figure 16 RCP Step 2

The right camera measures the distance to the right target, the left camera measures the distance to the left target, and the memory has the fixture length. We have 3 of the 4 sides of a trapezoid, and through application of mathematics we can determine the fourth – RCP. We also recheck our calculations several times by placing the fixture back on the runways at different points before proceeding.

Step 3. Recheck the Fixture Length

The RCP procedure establishes the missing dimension that allows side-to-side determination – each camera's position with respect to each other. The accuracy of this calculation is highly dependent on the fixture being dimensionally stable as we move it from point to point on the rack. The final step is to recheck the fixture to make sure it is the same length as we found in step 2.

We do this by placing the fixture on the left runway so that both targets are in the visual field of the left camera (see *Figure 17*). Certainly, if we measure with one camera, then measure with a different camera and get the same values we can be sure the fixture has remained stable and our RCP is valid.

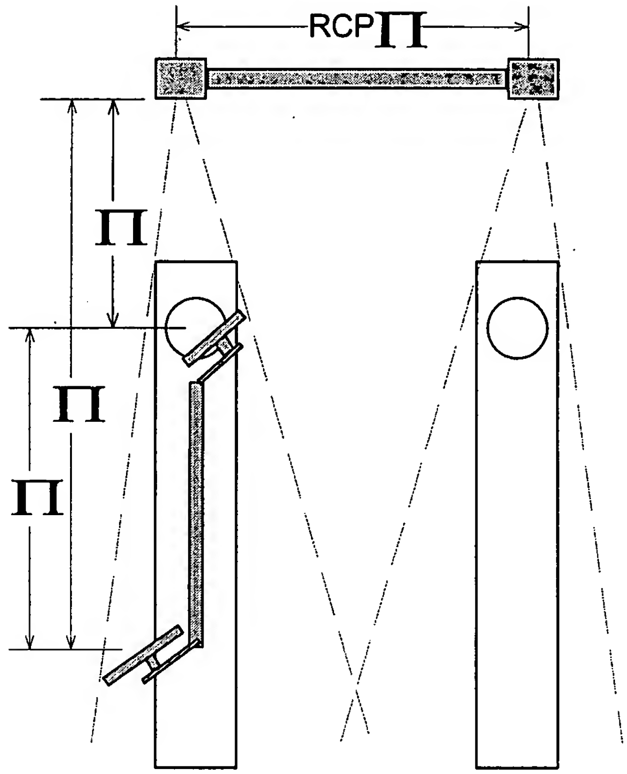

Figure 17 RCP Step 3

If the final check reveals the fixture has changed dimensions during the process we are given notice and must repeat the RCP procedure from the beginning.

Because the Camera Beam is rigid, the cameras are hard-mounted to the beam. And the structure is away from the action, the system does not require periodic maintenance calibration. The only way the accuracy of the RCP can be affected is if one camera moves with repect to the other – not likely to happen in every day usage.

Modeling the Vehicle in 3-Dimensional Space

After Positioning is completed, and the program is able to relate one side of the vehicle to the other, the software knows 4 distinct points that create a plane in space that are part of the vehicle. It takes these points and creates a 3-dimensional model of the vehicle plane. From this model, all alignment angles, caster, SAI, camber, and toe are referenced to the vehicle plane. This is contrast to conventional measuring-head aligners that use gravity or the rack surface as a reference. For this reason, the 3-D Aligner does not rely on a level lift. In reality, the aligner does not require gravity to measure, but our vehicle's physical state will change radically in a weightless environment.

Setup Utilities

Setup utilities are used primarily during aligner installation. There are a couple of test routine that is useful during diagnostics. Setup Utilities are also used after the cameras have been removed and replaced. The functions are decribed briefly below – see the Installation Manual for more details.

```
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                              Setup utils

Camera Aim                              RCP Check
Rel Cam Pos (RCP)                       Return to Main Menu
Target Id. (CLAWS)
Left Camera Test
Right Camera Test

 Use Arrow Keys to position on selected menu item. Use ENTER to select.
```

- Relative Camera Position (RCP) — This procedure is the primary "calibration" component of the 3-D Aligner. Once performed, the position in space of each camera with respect to one another is known. This enables the aligner to precisely measure wheel alignment angles based on target position and orientation. Refer to the 3-D Aligner Installation Instructions for details on how to perform RCP.

- Target ID (Claws) — The aligner can determine the position of the targets in space, but in order to relate this to the alignment angles it must know where plane of the wheel is. Since the targets attach to the wheel via the claws, we must know where the claw plane is with respect to the target. To some degree, we know where the claw plane is because we design and build the clamp/target assembly, and this information is included in the alignment program as the "default". Due to manufacturing tolerances, each assembly is slightly different – usually not enough to cause an error. Performing Target ID upon installation of a new target ensures total accuracy by determining the claw plane for that specific target/clamp assembly. Refer to the 3-D Aligner Installation Instructions for details on how to perform TID.